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DETERMINATION OF THE FLIGHT EQUIPMENT
MAINTENANCE COSTS
OF COMMUTER AIRLINES

NASA CR-152069

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V/STOL Systems Office
Ames Research Center
National Aeronautics and Space Administration
Moffett Field, California 94035

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i

TABLE OF CONTENTS

	<u>Page</u>
PREFACE	ii
I. INTRODUCTION	1
II. MAINTENANCE PRACTICES	3
III. ANALYSIS OF MAINTENANCE DATA	12
IV. SUMMARY	22
V. AREAS FOR FUTURE WORK	23
REFERENCES	24
APPENDIX A - The Commuter Airline Industry	25
APPENDIX B - Some Cost Estimating Relationships	31
APPENDIX C - Maintenance and Operating Data from Reference 1 Study	32
APPENDIX D - Maintenance and Operating Data from Present Study	33

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ii

PREFACE

This study of Flight Equipment Maintenance Costs of Commuter Airlines was conducted under the NASA Ames Research Center Contract A-36079-B(TS). The purpose of the study was to examine the airframe and engine maintenance costs and procedures for selected commuter airlines. The study is an extension of earlier work sponsored by the NASA Ames Research Center entitled A Study of Commuter Airline Economics, conducted by Summerfield Associates. This report presents the findings of the work completed by Summerfield Associates during the course of this study.

The principal investigator for the study was Dr. John R. Summerfield. The study was administered by the V/STOL Systems Office, NASA Ames Research Center, Moffett Field, California. Mr. Joseph L. Anderson was the Technical Monitor. Mr. Anderson's advice and assistance are gratefully acknowledged.

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1.

I. INTRODUCTION

In 1976, the NASA Ames Research Center sponsored a pioneering study of commuter airline economics (Reference 1). That study developed cost estimating relationships for direct operating costs of flight crew, fuel, oil and taxes, hull insurance, flight equipment maintenance, depreciation of flight equipment; and for indirect operating costs. The results were based on cost data acquired from ten cooperating commuter airlines. The cooperating airlines were among the larger passenger carrying commuters, carrying about 25% of the commuter passenger traffic in 1975.

Because aircraft maintenance costs are so important in the total cost structure of commuter airlines and because timely maintenance affects efficient operation of an airline, the present study was undertaken to determine these maintenance costs in more detail. Detailed analysis of maintenance activity will enable the NASA to identify areas in which more research could result in substantially reduced operating costs. A side benefit of the study would be to provide to aircraft designers and to government regulators and policy makers a more accurate means of estimating commuter airline operating costs. Thus, instead of dealing only with total maintenance costs, it would be considerably more useful to understand how airframe, engine, and avionics maintenance costs (both labor requirements and material costs) vary with flying activity. It has been

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2.

the purpose of the present study to explore these disaggregated maintenance costs for a select sample of commuter airlines.

It was the intent to concentrate this study effort on California-based commuter airlines since they were close at hand and there was little assurance that the desired detailed maintenance data were available. As the study progressed, it became clear that maintenance data in the necessary detail were available from only two commuter airlines within California. Hence, several airlines outside the state were added to the study.

Although the data base for this study was somewhat smaller than expected, the study succeeded in breaking new ground on commuter airline operating analysis. Some typical maintenance practices are delineated and detailed cost trends developed. This new information is discussed in the sections that follow.

For the reader not familiar with the commuter airline industry, Appendix A contains a description of the industry and some of its operations.

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3.

II. MAINTENANCE PRACTICES

Because of the diversity in size, aircraft type, and management among the many commuter airlines, any generalizations about maintenance practices must be treated with caution. Maintenance practices described in this section are based upon observations and on discussions with maintenance and operations executives of twelve commuter airlines. These interviews were conducted in the course of obtaining cost and operating data for this study and its predecessor. The airlines ranged in size from one carrying an average of 42 passengers per day to one carrying 1,100 per day. Two of the airline fly only piston-engine aircraft. The remaining airlines in the sample fly turbo-props. Geographically, the airlines cover the more densely populated areas of the United States.

Maintenance practices of commuter airlines can be differentiated from airline to airline, depending on aircraft type flown. The larger airlines fly such turbo-prop aircraft as the De Havilland Twin Otter, the Beech-99, the Swearingen Metro, the Nord 262, and the Short Brothers SD 3-30. Piston engine aircraft used are the De Havilland Heron, the Piper Chieftain, the Piper Seneca, and a wide variety of others. In addition, several of the commuter carriers operate under exemption authority from the Civil Aeronautics Board (CAB) allowing them to fly aircraft carrying more than 30 passengers. Those airlines operating with exemption authority and flying Convair 440 and 580 aircraft,

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4.

and Douglas DC-6 aircraft were not included in this study.

Many commuter airlines began as fixed base operators using available owned or leased aircraft for charter to groups or individuals for flights from the airport on which their fixed base operation was located. Frequent charter trips to the same destination provided the impetus that led the fixed base operator to initiate a regularly scheduled service. Thus he changed his status to that of a commuter airline. Those commuter airlines that started out in this fashion usually remain fixed base operators in addition to their commuter airline activities.

As fixed base operators, therefore, they often continue to maintain aircraft for other tenants or transients at their base. Most fixed base operators separate revenues and costs of fixed base services from those of their commuter airline operations. The separation of costs, however, is not always complete nor very accurate. For example, the maintenance man hours required on the part of one fixed base operator to fuel transient aircraft, a responsibility he carries on as part of his fixed base operation, are lumped into the costs for similar services performed on his commuter aircraft. The practice results in an overstatement of total maintenance cost in his commuter airline accounting records.

When outside maintenance is performed for transient or other aircraft not part of the commuter operation, it is common practice to charge the outside aircraft owner for the actual maintenance labor and materials cost, with a percentage added to cover overhead. Then, in the accounts of the commuter air-

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5.

line these costs are subtracted from the total maintenance cost. It is the assumption of the airline management that the remaining maintenance costs are sufficiently representative of the cost of maintaining the commuter aircraft.

It should be remembered that commuter airlines are not regulated and, therefore, are not required to maintain nor to report their operating costs. The care and detail with which the separation of costs is carried out depends upon the judgment and the financial arrangements and need of the owners, who may be both the fixed base operator and the commuter airline operator. If there is no management need to separate costs for internal control purposes, it is not likely to be done since it entails trouble and expense to do so.

Airframe

For the most part, commuter airlines do their own airframe maintenance within their own maintenance facilities. This airframe maintenance even extends to the major overhauls and to major modification programs that may be required because of aging of the aircraft or because of Federal Aviation Administration (FAA) directives. In order to perform this level of airframe maintenance, the commuter airline is required to have not only its facilities but also its maintenance personnel certificated by the FAA. The certificated operator can also perform contract maintenance for others if he so wishes.

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6.

The operation and maintenance of aircraft used as common carriers requires that various components and parts be inspected, repaired, or replaced at specified intervals defined by an FAA-approved maintenance procedure and program. The repair or replacement interval is usually designated by the number of flying hours or take-offs. In order to comply with FAA requirements, it is necessary to keep accurate records, such as the number of hours on those "time change" items. The majority of commuter airlines included in this study maintain such records manually, but a few of the larger ones have converted to some type of computer-based records. As aircraft become more complicated and the number of aircraft and time change components increases, the pressure for even small airlines to mechanize this portion of the record keeping process increases.

Spare parts inventory also tends to be handled on a manual basis and control is maintained for the most part by the knowledge, experience and foresight of the chief maintenance officer of the airline. Relatively little use is made of any inventory control systems, economic lot size ordering, or other advanced techniques of inventory control.

Major overhauls or major modifications required by the FAA may take place as infrequently as once every two or three years. Accordingly, maintenance actually performed on the airframe during a particular accounting period may not accurately reflect the maintenance requirements for the airframe on an average yearly basis. That is, if a major overhaul is required

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7.

once every 5,000 hours and the aircraft flies 2,000 hours during the year, then, on the average, once every 2-1/2 years each of those planes must undergo a major overhaul. For two years there may be relatively low maintenance costs followed by a fairly large increment in the third year. To be accurate in the allocation of maintenance costs to flying programs, it is desirable to set up a reserve for overhaul and to handle maintenance costs in a manner similar to the way depreciation costs are handled. That is, this method would write off the expected costs at a uniform rate over a period of time. Some of the larger commuter airlines are now following this practice in their accounting for airframe maintenance.

Engine

Typically, commuter airline operators of turbine engine aircraft do not perform their own major engine maintenance, although they do perform minor maintenance of engines when required. Thus, many of the engine manufacturers have set up exclusive franchise engine overhaul facilities and it is to these contractors that the commuter airlines send their engines for overhaul. The engine maintenance done in-house, then, is relatively minor and consists of removal and replacement of the engine or of some components.

For those turbo-prop engines that are manufactured abroad, as is the case of the engines in the Nord 262, the time lag required for removing engines, shipping them back to France,

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8.

and awaiting their return after overhaul is about 6-months. Accordingly, at least one operator of the Nord 262 is contemplating setting up an engine overhaul facility in order to reduce the large spare engine inventory occasioned by these long transit and repair lead times.

Most commuter airlines that fly piston engine aircraft have their own engine overhaul and repair shops and thus undertake complete engine maintenance themselves.

Engine maintenance, like airframe maintenance, is generated both by flying and by landings and takeoffs. One airline reports, for example, that the FAA regulations require that the hot sections of its turbo-prop engines be replaced every 18,000 operations. In other words, that portion of the maintenance cost is more a function of the number of landings and takeoffs than of the number of flying hours. Since engines run at maximum power or thrust during takeoffs, the total number of flights may be one of the major causes of engine maintenance. However, the number of such maximum horsepower or thrust operations and the total flying time both determine when maintenance must be performed.

Unlike airframe maintenance accounting, accrual of expected engine overhaul costs is a common form of accounting for engine maintenance. This is done by setting up an account usually called an Air Worthiness Reserve, the purpose of which is to spread fluctuating engine maintenance costs uniformly over

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9.

actual engine flying hours. The Air Worthiness Reserve (or reserve for engine overhaul, to give it a more appropriate title), accumulates costs and spreads them at a fixed hourly rate. This rate can be adjusted from year to year to reflect the impact of inflation or aging or other factors that would cause long-run changes in the average hourly cost to maintain the engines. Thus, the Air Worthiness Reserve distributes uniformly, over the period of engine use, otherwise widely fluctuating engine maintenance costs.

Avionics and Instrument Maintenance

Aircraft used in airline service are equipped with quite sophisticated avionics and instruments. Their repair requires fairly expensive calibration and adjustment equipment, as well as highly skilled maintenance personnel. For this reason, many of the smaller commuter airlines contract out the bulk of their avionics and instrument maintenance. As they became larger and they require more aircraft, they begin to train an individual to do the relatively limited minor maintenance operations. A few of the larger commuter airlines have their own fully equipped avionics and instrumentation shops and, with the exception of an occasional job which requires very expensive though infrequently used calibration equipment, they will do most of the maintenance on the avionics and instruments within their own shops.

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10.

Although these maintenance costs are typically recorded on shop orders, many airline accounting systems do not retain the separate identity of these costs. Instead, they are merged with other maintenance costs.

Ground Support Equipment

Most of the commuter airlines also maintain their own ground support equipment such as tows, fueling vehicles, baggage carts, trucks, and other maintenance equipment. Maintenance costs of this equipment are usually not separately reported but are included in the total airframe engine maintenance costs. The austerity of most commuter maintenance activities often leads to repair of ground support equipment only when it fails to operate properly.

Maintenance Burden

For those commuter airlines that operate only a single aircraft type, the distinction between direct maintenance and maintenance burden becomes a fine point of accounting practice often not of great importance either to the maintenance director or to the accountant. Hence, analysis of maintenance costs to handle direct maintenance separately from maintenance burden is difficult at best and often impossible. Each airline has a different concept of how to account for maintenance costs. Yet, for those airlines utilizing more than a single aircraft type, some method should be employed to allocate the overhead or burden to each aircraft type. Otherwise, it is not possible to assess relative profitability of various aircraft that are in operation or that are under consideration for future procurement.

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11.

Accounting

The CAB requires certificated airlines to file detailed financial and operating data in accordance with a standard Chart of Accounts. Recently, the Commuter Airline Association of America (CAAA), through an Ad Hoc Committee, has developed a proposed standard accounting system for its members.

(Reference 2). Although the CAAA suggests that its members adopt the new system, there is no present compulsion to do so. Each airline will balance its information needs and reporting requirements with the costs of accumulating the necessary data. In time, it is anticipated that greater uniformity of accounting practice will result from adoption of the new system.

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12.

III. ANALYSIS OF MAINTENANCE DATA

The primary objective of the present study was to obtain maintenance data for a representative group of commuter airlines in a form that would permit analysis of their costs separately by labor and material and separately within these two categories by airframe, engine, and other (mostly avionics and instruments). Commuter airlines queried that were appropriate to include in this study were too few in number to yield meaningful cost estimating relationships. Of the five California-based airlines contacted, only two airlines had recorded data that were in a form that would permit any detailed analysis. The other three have indicated that they are in the process of developing better cost data systems so as to improve management control. This in turn will provide better cost and operating data for any future studies.

Maintenance Costs for two California Carriers

Of the two commuter airlines that maintain detailed breakdowns of flight operations and maintenance cost data, one operated a fleet of De Havilland Twin Otter turbo-prop aircraft. The other operated a fleet of De Havilland Heron piston engine aircraft. Table I and II list in percentages the distribution of maintenance costs for the two carriers.

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13.

TABLE I Example of Distribution of Commuter Airline
Maintenance Costs for Turbo-prop Aircraft

	<u>Labor</u>	<u>Material</u>	<u>Purchased Services</u>	<u>Total Direct</u>
Airframe	13.4	3.2	8.1	24.7
Engine	6.1	2.4	48.2	56.7
Other	<u>8.0</u>	<u>7.9</u>	<u>2.7</u>	<u>18.6</u>
TOTAL DIRECT	27.5	13.5	59.0	100.0%

TABLE II Example of Distribution of Commuter Airline
Maintenance Costs for Piston Engine Aircraft

	<u>Labor</u>	<u>Material</u>	<u>Purchased Services</u>	<u>Total Direct</u>
Airframe	27.7	23.5	--	51.2
Engine	16.1	27.1	--	43.2
Other	<u>2.5</u>	<u>2.6</u>	<u>0.5</u>	<u>5.6</u>
TOTAL DIRECT	46.3	53.2	0.5	100.0%

Although these two distributions may not be typical of their respective categories of aircraft nor of other airlines, the differences are interesting:

Section II of this report stated that turbo-prop engines are typically overhauled by an outside contractor. Operators of piston engine aircraft, on the other hand, typically overhaul their own engines. Both examples cited here conform to that typical pattern. This difference alone could account for differences in the relative magnitude of labor and material costs reported by the two carriers. One

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14.

should note that differences in relative cost of engine maintenance shown in the two tables may be distorted since the piston engine Heron is a four-engine aircraft and the turbine powered Twin Otter is a two-engine aircraft. Also airframe and engine labor and material costs for the Heron may be higher than similar costs for operators of newer aircraft since the Herons are more than 25-years old.

Total direct maintenance costs per flight hour for the turbo-prop carrier were 60% higher than those for the piston engine carrier. Costs per pound of aircraft weight per flight hours were more than 90% higher for the turbo-prop carrier. The average length of hop, however, was four times as great for the piston engine operator. That is, the number of landings and take-offs per flight hour were about four times as great for the turbo-prop operator. Flight hours and landings and take-offs all contribute to maintenance work loads.

Relationship of Data to Previous Work

Reference 1 derived an equation for estimating maintenance costs per flock hour as a function of the aircraft operators' weight empty. A tabulation of all the equations derived in Reference 1 is provided in Appendix B.

Because of inflation, use of equations based on 1975 data would be expected to underestimate 1976 data recorded in this study. An approximation of the impact of inflation on

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15.

maintenance costs was derived from the cost indexes for labor and for aircraft maintenance materials, as computed quarterly by the Air Transport Association of America (ATA). According to that source, airline labor costs were 10.1% higher in 1976 than in 1975 and maintenance material costs were 7.0% higher in 1976 than in 1975. Those factors were combined into an average of 8.5% inflation for maintenance costs and this was the value assumed. Although it is not known whether the ATA index is representative of inflation trends among non-certificated carriers, these indices are the best available known to the authors.

In Reference 1, 1975 data from ten commuter airlines, all of whom operated turbo-prop aircraft exclusively, provided the basis for derivation of the following cost estimating relationship:

$$\frac{\text{TME}}{\text{BLOCK HOURS}} = 3.14 \left(\frac{\text{OWE}}{10^3} \right)^{1.21}$$

where TME = Total annual maintenance cost, including maintenance burden, in dollars.

OWE = Operator's weight empty per aircraft, in pounds.

BLOCK HOURS = Total annual block hours.

Data utilized in derivation of the above equation are tabulated in Appendix C. To preserve the proprietary nature of the data, the airlines have been coded from 50 through 59.

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16.

Appendix D tabulates the 1976 cost data collected from five airlines during this present study. These latter airlines' data have been coded from 60 through 64.

In order to test the applicability of the maintenance equation developed in the earlier study, that equation was utilized to compute total maintenance cost per block hour for the five airlines in the present study, using operator's weight empty as the independent variable.

Figure 1 shows the relationship between actual maintenance costs and those calculated from the TME equation of Reference 1. Points falling on the 45° line represent cases in which the cost estimating equation precisely estimates the actual maintenance cost per block hour for an airline. Points below the 45° line represent airlines for which the cost estimating equation underestimated actual costs while points above the 45° line represent airlines for which the cost estimating equation overestimates actual costs.

The points marked + are the data points from Reference 1 and the points marked $\otimes$ are maintenance costs for the carriers included in the present study. Four of the five 1976 data points fall below the line that represents perfect cost estimation. Although the sample size is too small to permit reaching definitive conclusions, the equation derived in Reference 1 provides a first order approximation of maintenance costs. A better inflation factor might improve the predictive use of the equation. Lastly, even though the equation

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17.

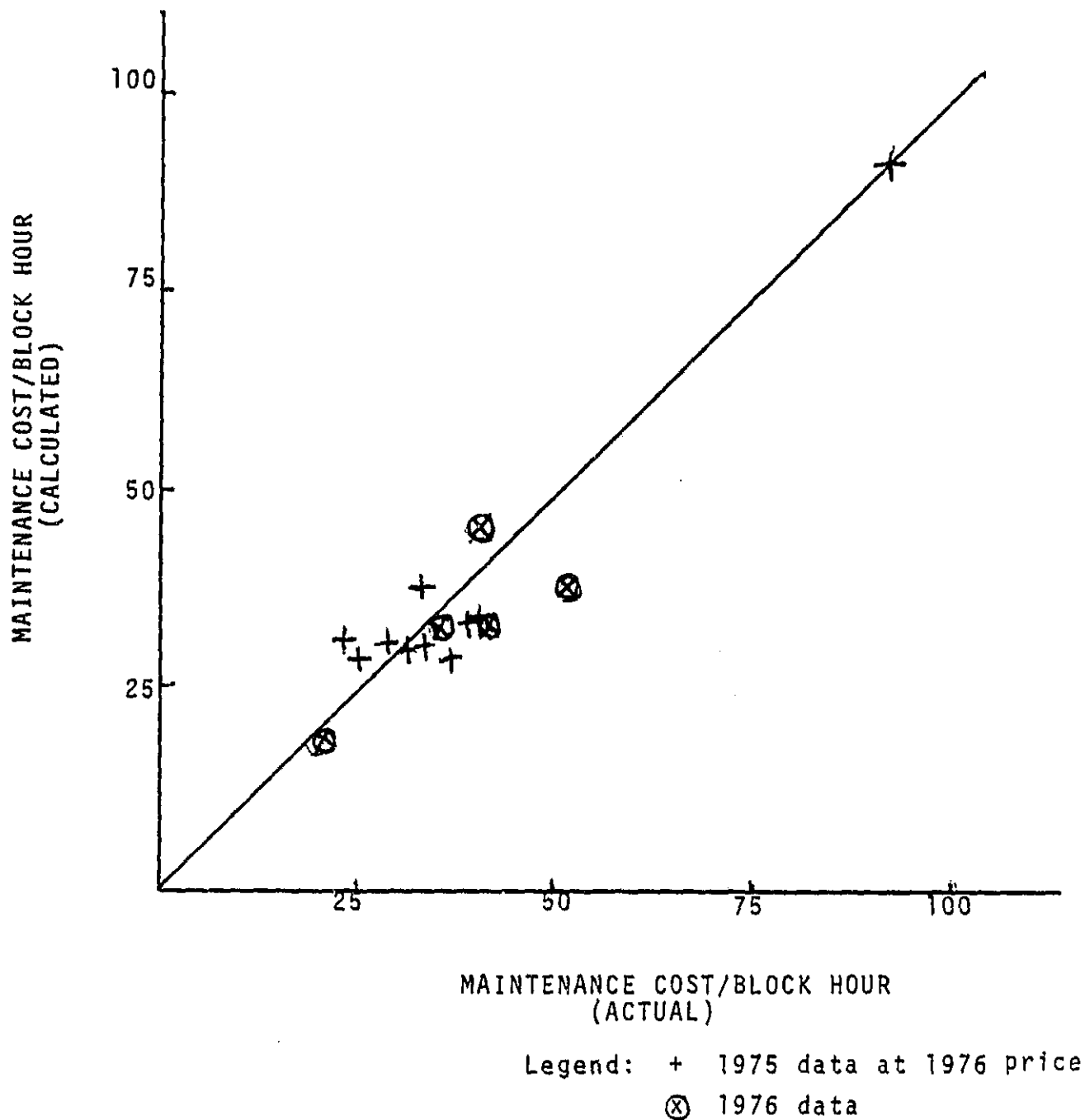


FIGURE 1
Comparison of Actual and Calculated Costs

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18.

derived in Reference 1 was developed exclusively from airlines with turbo-prop equipment, application of that equation to the present sample of two piston engine and three turbo-prop operators does not appear grossly inaccurate.

Further analysis of the entire data of Appendices C and D was made by inflating the 1975 data from Reference 1 at 8.5% and then deriving a new maintenance cost equation based on all fifteen airlines. A resulting equation, of the same form as that derived in Reference 1, is:

$$\frac{\text{TME}}{\text{BLOCK HOURS}} = 4.43 \left(\frac{\text{OWE}}{3} \right)^{1.10}$$

Figure 2 displays the data from which the above equation was derived. It is noteworthy that thirteen of the fifteen data points represent airlines flying aircraft of approximately the same weight; namely, Twin Otters, Beech 99s, and Swearingen Metros. The equation derived in Reference 1 included the heavier Nord 262 but not the lighter Piper Chieftain and Seneca aircraft included in the present study. That difference accounts for a portion of the difference between the above equation and that derived in Reference 1. If an equation of the same form is to be used to estimate future maintenance costs, the sample of airlines used to derive the equation should include more airlines flying larger aircraft (e.g., Nord 262s

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19.

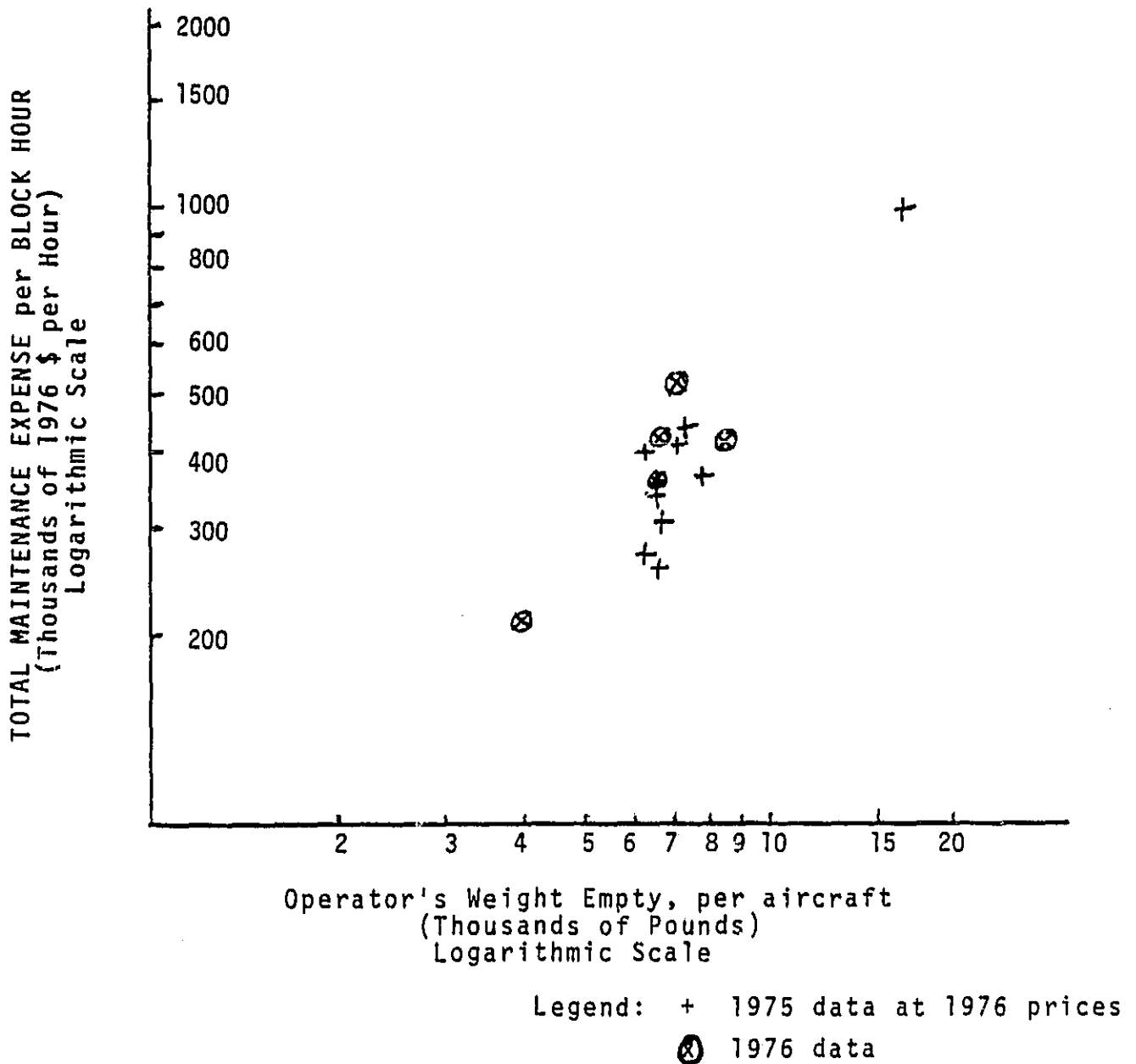


FIGURE 2

MAINTENANCE EXPENSE per BLOCK HOUR
VS. OPERATORS WEIGHT EMPTY

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20.

or Shorts 3-30) and more airlines flying smaller aircraft (e.g., Pipers, Cessnas or Norman-Britten Islanders).

Using the full sample of data from both Appendices C and D, several other relationships were explored. One refinement that provided a slightly better fit to the data was found to be:

$$TME = 4.53 (\text{Block Hours})^{0.997} \left(\frac{OWE}{10^3} \right)^{1.10}$$

Since the exponent of the Block Hour term is so close to unity, one would expect the equation to closely resemble the earlier one, as it does.

The discussion in Section II of this report suggests that an estimating equation for Total Maintenance Expense should include not only aircraft weight and block hours but also the number of departures. The latter variable is generally believed to be important because landings and take-offs produce the greatest stress on engines, landing gears, and tires, among other parts. Data in Appendices C and D show that the number of departures per flight hour range between 0.95 and 2.92 for the airlines in the study and one would expect both departures and flight hours to affect maintenance costs. Attempts to derive equations utilizing all these variables (weight, hours, and departures) yielded very poor fits to the data in some cases and nonsense relationships in others (e.g., maintenance costs increasing as the number of departures decrease).

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21.

The above indicates that use of aircraft weight and block hours as measures of maintenance cost are not sufficient. More details of the nature of the maintenance costs as well as aircraft departures and/or flight hours are desirable in order to develop better cost estimating relationships. In addition, larger and more representative samples are essential.

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22.

IV. SUMMARY

This study of commuter airline economics has built upon the base developed in an earlier NASA, Ames Research Center, sponsored study. This current study was to include a detailed survey of the maintenance practices of several commuter airlines of varying size operating a variety of small aircraft. Two of the commuter airlines included in the study were able to provide maintenance costs in sufficient detail to permit an analysis separately by airframe, engine, and other and, within each category, separately by labor, material, and purchased services. These results indicate differences between turbo-prop and piston engine equipped aircraft maintenance costs, but no general conclusions should be drawn.

In the course of obtaining detailed maintenance cost data, much subjective information was obtained about commuter airline maintenance procedures. This information has been summarized, and it will be helpful in explaining maintenance cost data as better data become available. The Commuter Airline Association of America has developed a Uniform System of Accounts and Reports for Commuter Airlines. As more airlines adopt the uniform system, better and more nearly consistent cost data will be readily available.

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23.

V. AREAS FOR FUTURE WORK

Rapid growth of the commuter airline industry coupled with the likelihood that commuters will be eligible for subsidy makes it necessary for the government to have good estimating tools for analysis, evaluation, and possibly regulation of commuter airlines. The present study and its predecessor study (Reference 1) provide a basis for undertaking the necessary further work.

Future work should include:

1. Selection of a large enough sample of mature airlines to include a wide range of aircraft types. From this sample of airlines, maintenance costs should be obtained in sufficient detail to permit analysis separately by airframe, engine, and other and, within each category, separately by labor, material, and purchased services.
2. Development of separate cost estimating relationships for turbine powered aircraft and for piston engine aircraft.
3. Data from turbine engine overhaul contractors.
4. Development of inflation factors for the commuter industry rather than relying on ATA cost indexes.
5. Analysis of the content of all maintenance accounts to assure comparability among carriers and proper assignment of direct and indirect costs.

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24.

In summary, there is a growing need for an understanding of the economics of commuter airlines. Subsidy eligibility of commuters, resulting from certification or from provisions of the proposed regulatory reform legislation, necessitates improved cost estimating methods. Aircraft and engine designers, seeking to keep U.S. dominance of the airframe industries of the world, also need better tools for evaluating alternative technology for small planes. Additional analytic work, beyond that provided in the earlier study (Reference 1) or the present study, will be required to meet these demands.

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25.

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3. Commuter Air Carrier Traffic Statistics, Year Ended December 31, 1976, Civil Aeronautics Board, June, 1977.

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26.

APPENDIX A

THE COMMUTER AIRLINE INDUSTRY

The Civil Aeronautics Board (CAB) defines a commuter air carrier as an "operator which (1) performs at least five round trips per week between two or more points and publishes flight schedules which specify the times, days of the week and places between which such flights are performed, or (2) transports mail by air pursuant to a current contract with the U.S. Postal Service." Commuters are permitted to operate aircraft seating no more than 30 passengers with a payload capacity of no more than 7,500 pounds. Under its exemption authority, the Board also has the right to permit commuters to operate larger aircraft to satisfy the needs of specific markets.

Commuter airlines hold operating certificates issued by the Federal Aviation Administration (FAA) and operate aircraft under all applicable federal air regulations. At the present time commuter airlines are not subsidized by the Federal Government. Their reporting requirements to the CAB and the FAA are minimal, consisting of some traffic and operating data and schedules, but no operating cost data.

Some states regulate intra-state operation of commuters, including route protection provisions and control of fares, cargo rates and other charges.

The commuter airline industry consists of about 250 small airlines registered with the CAB under Part 298 of its Economic Regulations.

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27.

Commuter airlines serve 781 airports and 2090 city-pairs (Reference 3). Their operation is integrated into the U.S. air transportation network of trunk and local service carriers by listings in the Official Airline Guide, by the publishing of joint fares, and by extensive inter-line arrangements. A substantial portion of the traffic carried by commuter airlines connects to trunk or local service airlines at hub airports for travel to or from more distant points. Much of the traffic however, travels only between points served by the commuter airlines. For a large number of markets a principal competitor is the private automobile, bus, or train, since distances are relatively short. One characteristic of the operation of a commuter airline is frequent service with small aircraft in well-traveled markets.

The commuter airline industry is undergoing rapid change. Between 1970 and 1976, commuter passenger traffic grew at an average annual rate of 9.4%, nearly double the annual growth rate of 5.0% for certificated air carriers in scheduled domestic service. This rapid growth rate poses a number of major problems for the industry and for the U.S. Government. Changing aircraft size limitations proposed in various airline regulatory reform bills now before the Congress, for example, will open new aircraft possibilities for commuter use.

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28.

Reference 3 lists 252 commuter airlines, of which only 147 reported traffic data for the full year 1976. Table A-I summarizes commuter service in 1976.

TABLE A-I

<u>Type of Service</u>	<u>Number of</u>		
	<u>Carriers</u>	<u>Airports</u>	<u>City-Pairs</u>
Passenger only	34	62	451
Cargo only	31	43	327
Mail only	32	80	245
Passenger and Cargo	85	300	746
Passenger and Mail	3	12	19
Cargo and Mail	15	36	106
Passenger, Cargo, and Mail	52	248	196
TOTAL	252	781	2,090

The ten largest commuters (measured by number of passengers boarded) carried 42% of the total number of passengers carried by all commuters. The twenty-five largest carried over two-thirds of the passengers. Eighty of the 174 passenger carriers carried fewer than 14 passengers a day while 28 carried more than 300 passengers a day. In 1975, 78% of the markets served by commuter airlines boarded fewer than 10 passengers per day; only 1.3% boarded more than 150 passengers per day.

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29.

In 1976, commuters carried 7.3 million passengers an average of 105 miles each. This compares with 37.9 million passengers and average trip length of 320 miles for local service airlines in the same year. Commuters also carried 215 million pounds of cargo and 109 million pounds of mail.

Because commuter airlines have not adopted a uniform chart of accounts, they have been free to develop their own accounting methods. Although many of the larger commuter airlines have adopted accounting systems based in large measure on the CAB Form 41 accounting system, most commuters, including almost all of the smaller operators, have developed individual accounting systems, each geared to the needs and control philosophy of management. This diversity of systems is in part a result of the fact that the companies comprising the bulk of the industry are young and growing. Many are privately owned and are reluctant to share cost information. This is particularly the case of those commuters that are not regulated by the states - the bulk of the commuters - and hence have no route protection for the markets they serve.

Recently, a committee of the Commuter Airline Association of America has developed a uniform chart of accounts for voluntary adoption by members of the Association. This system is an adaptation and simplification of the CAB Form 41 chart of accounts. To the extent that the industry adopts the new system, future industry costing studies will be facilitated.

The regulatory reform legislation, referred to above, will require the U.S. Government to have a much more detailed knowledge of the economics of commuter airline operation than now exists. One provision of the legislation now under consideration, for example, is the provision of subsidy for airlines that serve communities abandoned by trunk or local service carriers. Section 12(a) of the Senate draft of an "Air Transportation Regulatory Reform Act of 1977" states that the CAB shall include expense elements based upon representative costs of air carriers providing scheduled air transportation of persons, property, and mail, using aircraft no larger than the type and characteristics specified under Section 419." Section 419 specifies size limitations for eligible commuter-type aircraft.

In order to monitor both subsidy requirements and subsidy payments, it will be necessary for the Government to have accurate information on the economics of the industry.

Additionally, a number of commuter airlines have recently requested certification that would entitle them to government guaranteed loans as well as subsidy. For all of these reasons a better understanding of the economics and the cost structure of commuter airlines is essential.

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31.

APPENDIX B

Some Cost Estimating Relationships

These equations, developed in Reference 1, describe cost relationships of commuter airlines flying turbo-prop aircraft falling within the limitations of Civil Aeronautics Board Economic Regulations, Part 298. The equations are based on 1975 cost data expressed in 1975 dollars.

DIRECT OPERATING COST:

Flight Crew Expenses:

$$FCE = 21,060 \left(\frac{\text{ANNUAL AVAILABLE SEAT MILES}}{6 \times 10^6} \right)^{0.91}$$

Fuel Oil and Taxes:

$$FOT = \left[\left(\frac{\text{FUEL CONSUMPTION}}{\text{RATE}} \right) \left(\frac{\text{FUEL COST}}{\text{GAL}} \right) (1.045) \right] \left(\frac{\text{ANNUAL BLOCK HOURS PER AIRCRAFT}}{\text{HOUR}} \right) \left(\frac{\text{FLEET SIZE}}{\text{AIRCRAFT}} \right) 10^{-6}$$

Hull Insurance:

$$INS = \left[\left(\frac{\text{AIRCRAFT UNIT COST}}{\text{UNIT}} \right) \left(\frac{\text{INSURANCE RATE}}{\text{PERCENT}} \right) \right] \left(\frac{\text{FLEET SIZE}}{\text{AIRCRAFT}} \right) 10^{-6}$$

Maintenance:

$$TME = \left[3.14 \left(\frac{\text{OWNERS WEIGHT EMPTY}}{3 \times 10^3} \right)^{1.21} \right] \left(\frac{\text{ANNUAL BLOCK HOURS PER AIRCRAFT}}{\text{HOUR}} \right) \left(\frac{\text{FLEET SIZE}}{\text{AIRCRAFT}} \right)$$

Depreciation:

$$DFE = \left(\frac{\text{AIRCRAFT UNIT COST}}{\text{UNIT}} \right) \left(\frac{\text{AIRCRAFT SPARES FACTOR}}{\text{PERCENT}} \right) \left(1 - \frac{\text{RESIDUAL VALUE}}{\text{PERCENT}} \right) \left(\frac{\text{FLEET SIZE}}{\text{AIRCRAFT}} \right) 10^{-6} \left(\frac{1}{\text{DEPREC. PERIOD}} \right)$$

INDIRECT OPERATING COSTS:

$$IOC/\text{DEPARTURE} = -6.16 - 23.67 \left(\frac{\text{ANNUAL NO. OF PASSENGERS}}{6 \times 10^6} \right) + 1.92 \left(\frac{\text{ANNUAL AVAILABLE SEAT MILES}}{6 \times 10^6} \right)$$

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32.

APPENDIX C

Maintenance and Operating Data From Reference 1 Study

<u>Air- line Code</u>	<u>Total Annual Main- tenance Cost (Thousands of 1975\$)</u>	<u>Annual Block Hours (Thousands)</u>	<u>Operators Weight Empty (Pounds/ Aircraft)</u>	<u>Departures per Flight Hours</u>
50	842	22.2	7100	2.51
51	636	18.9	7800	1.12
52	40	1.1	6300	0.95
53	1663	18.1	16,400	1.49
54	525	20.9	6300	1.61
55	898	22.5	7300	1.30
56	325	11.5	6700	2.36
57	404	12.1	6670	1.73
58	373	12.0	6600	1.63
59	128	5.3	6620	1.85

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33.

APPENDIX D

Maintenance and Operating Data From Present Study

<u>Air- line Code</u>	<u>Total Annual Main- tenance Cost (Thousands of 1976\$)</u>	<u>Annual Block Hours (Thousands)</u>	<u>Operators Weight Empty (Pounds/ Aircraft)</u>	<u>Departures per Flight Hours</u>
60	1397	26.8	7100	2.53
61	641	15.5	8500	1.62
62	162	7.6	4000	2.92
63	530	12.5	6700	1.93
64	451	12.6	6600	1.71